Editorial

THE PAST two decades have witnessed revolutionary advances in biomedical imaging modalities capable of providing biological and physiological information from the cellular scale to the organ level. Recent advances have also been focused on cost-effective, noninvasive, portable, and molecular-imaging technologies for imaging at microscopic, mesoscopic, and macroscopic levels. These technologies have significant potential to advance biomedical research and clinical practice. They can also provide a better understanding and monitoring of physiological and functional disorders, which could lead to mainstream diagnostic technologies of the future.

I. Scope of the Special Issue

This Special Issue addresses the emerging technologies in multiparameter biomedical optical imaging and image analysis. For this exciting area, this Special Issue invited contributions in the general areas of multiparameter, multidimensional optical microscopy, confocal microscopy, optical endoscopy and spectroscopy, fluorescence imaging and tomography, diffuse reflectance and transillumination imaging, optical coherence tomography, multiphoton imaging and microscopy, photoacoustic imaging and tomography, biophotonic imaging and tomography, and image analysis (segmentation, registration, classification, etc.). As a result of this call, we received a record number of 50 submissions that were reviewed by leading experts in their respective areas. Among the many meritorious submissions, 18 were selected to highlight and represent the breakthrough research at the leading edge of rapidly emerging technologies and scientific research work with high impact and novelty.

It should also be noted that the guest editors also organized a special session "Multi-parameter Biomedical Optical Imaging" as part of 2010 IEEE International Symposium on Biomedical Imaging: From Nano to Macro, 17 April 2010, Rotterdam, The Netherlands, where several exciting papers on this topic were presented.

II. Special Issue Papers

The papers in this Special Issue demonstrate some of the most exciting developments in optical imaging and image analysis from tissue to cellular and molecular levels.

Eleven papers dealing with multiparameter optical imaging and image reconstruction methods for most promising modalities such as optical coherence tomography (OCT), molecular fluorescence tomography, multispectral transillumination imaging, bioluminance tomography, and photoacoustic imaging are presented first in this Special Issue. These papers demonstrate novel optical microscopic and functional imaging methods for important tissue characterization and potential diagnostic applications.

Yao *et al.* present a simple method to numerically correct optical-axis calculation in polarization-sensitive OCT. Through experimental studies in tendon tissue, they demonstrate the application of their method to mapping the 2-D optical axis distributions in enface polarization-sensitive OCT images.

Yalavarthy *et al.* show that if *a priori* knowledge of the refractive index for the segmented regions of tissue, or even an approximated value, is used instead of assuming identical refractive index for all regions of tissue, then much accurate estimates of optical properties can be obtained.

Tian *et al.* address the problem of over smoothing due to Tikhonov regularization in fluorescence molecular tomography. They utilize a third-order simplified spherical harmonics approximation to radiative transfer equation to model the photon propagation within biological tissue.

D'Alessandro *et al.* present novel methods of recovering depth-dependent measurements from transillumination images obtained through the Nevoscope, estimating the depth-dependent point spread function, and ratiometric analysis for the quantification of oxy- and deoxy-hemoglobin. The presented methods can be used for reliable quantitative analysis of multispectral Nevoscope images for early detection of angiogenesis leading to early diagnosis of skin cancers.

Liu *et al.* address two issues to improve the quantitative assessment of blood-oxygen saturation level: implementation of a spectral normalization technique to eliminate the spectral modulation induced by the wavelength-distance dependent point spread function of OCTs and the reduction of the spectral speckle noise due to the highly scattering blood. They assess the effectiveness of their methods using common-path OCT system.

Wang *et al.* introduce a dual-modality imaging system by integrating optical-resolution photoacoustic microscopy and fluorescence confocal microscopy to provide optical absorption and fluorescence contrasts simultaneously. They demonstrate simultaneous photoacoustic angiography and fluorescence lymphangiography.

Tian *et al.* describe the analysis of quantitative reconstruction deviation from peak wavelength shift of luminescent source and the deviation of heterogeneous mouse model for bioluminescence tomography. They discuss that the reconstruction results are significantly affected by the peak wavelength shift and deviation of anatomical structure animal models, and the model deviations exhibit much more influence than the wavelength shift on the reconstruction results.

Yu *et al.* reformulate bioluminescence tomography as a least absolute shrinkage and selection operator (LASSO) problem with regularization, and propose a fast reconstruction algorithm named as stage-wise fast LASSO (SwF-LASSO) is to solve this problem. Through numerical simulations, they demonstrate

Digital Object Identifier 10.1109/TBME.2010.2072750

0018-9294/$26.00 © 2010 IEEE

that their algorithm is not sensitive to measurement noise, can achieve high computational efficiency, and accurately localize source even without any permissible region constraint.

Khan *et al.* develop an algorithm to estimate a single-line medial axis, the basis for computation of band profile representative of intensity distribution over chromosomes. They find their algorithm to be robust and capable of estimating a satisfactory single-line medial axis and band profile to be a good representative of intensity levels in different regions of chromosomes.

Gibson *et al.* present an automated method for nonrigid registration of the optical nerve head surfaces extracted from segmented 3-D OCT images. They illustrate construction of an average optical nerve head shape across an illustrative dataset.

Jo *et al.* report early favorable results from an animal study designed to measure the capacity of this approach for diagnosing oral cancer in a hamster cheek pouch model of oral cancer using their recently developed noninvasive imaging system incorporating OCT and fluorescence lifetime imaging to acquire both sets of biomarkers.

The remaining set of papers addresses the issues of image analysis for optical, radiological and histopathological image analyses. Although radiological and optical image analyses have attracted much of the attention in the past decades and enormous strides have been made [1], there are several challenging problems still remaining. Histopathogical image analysis, on the other hand, is truly an emerging area growing at an accelerated pace, especially after the introduction of commercially available whole-slide scanners. The size, complexity, scale, and biological richness of these images constitute both the advantages and challenges of this exciting field [2], [3].

Jung *et al.* present a novel watershed-based method for segmentation of cervical and breast cell images by formulating the segmentation of clustered nuclei as an optimization problem. By using *a priori* knowledge with respect to the shape of nuclei, they solve the optimization problem.

Lu *et al.* propose an automated retinal-layer-segmentation technique for OCT images. Their experiments with four objects demonstrate that their proposed technique segments the image into five layers accurately.

Samsi *et al.* develop a follicle detection method from immunohistochemically stained slides of follicular lymphoma using texture and color information to mimic the process that a human expert might use to identify follicle regions. They compare system-generated results with expert-generated ground truth and show promising results.

Sertel *et al.* address computer-aided detection of centroblasts for follicular lymphoma grading using adaptive likelihood-based cell segmentation. The proposed system uses a unitone conversion to obtain a single-channel image that has the maximum contrast and from the resulting image, a cell-likelihood image is generated in an adaptive way that is robust to variations using the estimated parameters associated with hematoxylin stain concentration of pixels.

Cooper *et al.* illustrate the challenges associated with analyzing and integrating large-scale image datasets with molecular characterizations. They present their methodology for addressing these challenges in the context of a study on diffuse glioma brain tumors, and present a motivating example for correlating nuclear morphometry with molecular characterization of glioblastomas.

Tian *et al.* investigate an approach for automatic liver segmentation from CT scans based on a statistical-shape model integrated with an optimal-surface-detection strategy. They apply their method to MICCAI 2007 liver segmentation challenge datasets.

Sadeghi Naini *et al.* propose a technique to enhance the quality of intraoperative ultrasound images of a deflated lung undergoing minimally invasive tumor-ablative procedure. The proposed technique employs information of a deflated lung's computed tomography image constructed preoperatively in order to enhance those of the intraoperative ultrasound images.

ACKNOWLEDGMENT

The guest editors would like to thank Prof. B. Wheeler, Editor-in-Chief of TBME for his encouragement, advice, and continuous support from the conceptualization of the special issue idea and throughout the review process. They are also extremely grateful to the reviewers who carefully reviewed the submissions and provided extremely valuable and constructive critiques while providing all the feedback in a timely manner even after unexpected delays in travel due to the volcanic eruption in Iceland and during several proposal submission deadlines.

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